Akira TAKAHASHI* & Michio TAMURA**: **An evolutional trend in dimension of the tracheary elements of the woody Polycarpicae**

高橋 晃*・田村道夫**: 木本性多心皮類の木部管状要素の長さと直径における進化傾向

The Polycarpicae are generally regarded as the most primitive group of the angiosperms containing Magnoliales, Illiciales, Laurales, Piperales, Trochodendrales, Ranunculales and so on. In the woody group, vesselless families such as Winteraceae, Trochodendraceae, Tetracentraceae, and Amborellaceae are included. It was already known that morphological features of the vessel elements and imperforate tracheary elements or "fibers" in the Polycarpicae vary considerably (Metcalfe & Chalk 1950, Takahashi 1985a, b, Metcalfe 1987). Some vessel elements have scalariform perforations at the steeply inclined ends and scalariform intervessel pits on the lateral walls, whereas some others have simple perforations at the nearly horizontal ends and alternate intervessel pits on the lateral walls. Some fibers have conspicuously bordered circular pits and some others have simple ones. According to the general trends of the vessel evolution, primitive vessel elements are very long and narrow, and as they advance, the length becomes shorter and the diameter wider (Bailey & Tupper 1918, Frost 1930, Bailey 1944). On the other hand, fibers become more or less shorter but not so much wider as they advance. Thus the difference between the length and the width of vessel elements and those of fibers becomes greater. In this study, we attempted to show evolutional trends in the tracheary elements, based on their length and diameter, in woody species and also in several herbaceous ones of the Polycarpicae.

Materials and methods In this study 29 species of 17 families in the woody Polycarpicae, including 6 vesselless species, and 8 species of 4 families in the herbaceous Polycarpicae were examined (Tab. 1). The wood samples used in

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Tab. 1. List of species examined.

No	Species	Families	Localities
1	Tasmannia piperita (Hook.f.) Miers	Winteraceae	Mt.Kinabalu, North Borneo
2	Belliolum crassifolium Tieghem	Winteraceae	Plateau de Degny, New Caledonia
3	Amborella trichopoda Baillon	Amborellaceae	Plateau de Degny, New Caledonia
4	Trochodendron aralioides Sieb. & Zucc.	Trochodendraceae	Mt.Ashitaka, Shizuoka Pref.
5	Drimys winteri Forst.	Winteraceae	Puerto Montt, Chile
6	Sarcandra glabra (Thunb.) Nakai	Chloranthaceae	Isl.Iriomote, Okinawa Pref.
7	Ascarina philippinensis C.Robinson	Chloranthaceae	Mt.Kinabalu, North Borneo
8	Hedyosmum orientale Merr. & Chun	Chloranthaceae	Padang, West Sumatra
9	Ascarina rubricaulis Solms	Chloranthaceae	Mont Dzumac, New Caledonia
10	Illicium anisatum L.	Illiciaceae	Kibune, Kyoto Pref.
11	Trimenia papuana Ridley	Trimeniaceae	Mt.Kaindi, Papua New Guinea
12	Eupomatia laurina R.Br.	Eupomatiaceae	Atherton Tableland, Queensland
13	Chloranthus spicatus (Thunb.) Maxim.	Chloranthaceae	Cult., in Osaka
14	Cercidiphyllum japonicum Sieb. & Zucc.	Cercidiphyllaceae	Hakone, Kanagawa Pref.
15	Galbulimima belgraveana (F.v.Muell.) Sprague	Himantandraceae	Mt.Kaindi, Papua New Guinea
16	Austrobaileya maculata C.White	Austrobaileyaceae	Atherton Tableland, Queensland
17	Schisandra repanda (Sieb. & Zucc.) Radlk.	Schisandraceae	Mt.Omine, Nara Pref.
18	Kadsura japonica (L.) Dunal	Schisandraceae	Mt.Omine, Nara Pref.
19	Degeneria vitiensis I.Bailey & A.C. Smith	Degeneriaceae	Near Suva, Fiji
20	Euptelea polyandra Sieb. & Zucc.	Eupteleaceae	Hakone, Kanagawa Pref.
21	Elmerrillia mollis Dandy	Magnoliaceae	Gunung Buduk Rakik, Kalimantan
22	Magnolia salicifolia (Sieb. & Zucc.) Maxim.	Magnoliaceae	Otaki, Nagano Pref.
23	Liriodendron tulipifera L.	Magnoliaceae	Cult., in Osaka
24	Magnolia sieboldii K.Koch	Magnoliaceae	Cult., in Tokyo
25	Magnolia hypoleuca Sieb. & Zucc.	Magnoliaceae	Hakone, Kanagawa Pref.
26	Cinnamomum camphora (L.) Presl	Lauraceae	Cult., in Osaka
27	Litsea citriodora (Sieb. & Zucc.) Hatus.	Lauraceae	Isl.Yaku, Kagoshima Pref.
28	Hernandia nymphaefolia (Presl) Kubitzki	Hernandiaceae	Isl.Ishigaki, Okinawa Pref.
29	Piper aduncum L.	Piperaceae	Mt.Kaindi, Papua New Guinea
30	Akebia trifoliata (Thunb.) Koidz.	Lardizabalaceae	Mt.Iousen, Toyama Pref.
31	Decaisnea fargesii Franch.	Lardizabalaceae	Cult., Washinton Arboretum
32	Paeonia suffruticosa Andrews	Paeoniaceae	Cult., in Osaka
33	Nandina domestica Thunb.	Berberidaceae	Cult., in Osaka
34	Mahonia japonica (Thunb.) DC.	Berberidaceae	Cult., in Osaka
35	Berberis thunbergii DC.	Berberidaceae	Mt.Tsurugi, Tokushima Pref.
36	Clematis stans Sieb. & Zucc.	Ranunculaceae	Mt.Kongo, Osaka Pref.
37	Clematis patens Morr. & Decne.	Ranunculaceae	Sanda, Hyogo Pref.

1-6. Vesselless: Species are arranged according to mean tracheid length. 7-29. Woody; 30-37. Herbaceous: Species are arranged according to mean vessel element length.

Tab. 2. Length of vessel elements and fibers, and F/V ratio.

Species	Length (μm) Vessel				Fiber				F/V Ratio
	Min.	Max.	Mean.	S.D.	Min.	Max.	Mean.	S.D.	
1 Tasmannia piperita	-	-	-	-	1600	4520	3364	607	1.0
2 Belliolum crassifolium	-	-	-	-	1850	3700	2847	457	1.0
3 Amborella trichopoda	-	-	-	-	1520	3320	2630	463	1.0
4 Trochodendron aralioides	-	-	-	-	2000	3130	2580	469	1.0
5 Drimys winteri	-	-	-	-	1470	3400	2560	479	1.0
6 Sarcandra glabra	-	-	-	-	740	2080	1582	219	1.0
7 Ascarina philippinensis	1720	3450	2467	343	1180	3600	2667	538	1.08
8 Hedyosmum orientale	920	2800	1909	446	1270	3100	2165	451	1.13
9 Ascarina rubricaulis	1020	2350	1636	340	1200	2630	1951	358	1.19
10 Illicium anisatum	580	1670	1191	226	660	1860	1329	228	1.11
11 Trimenia papuana	700	1750	1188	227	1175	2600	1878	302	1.58
12 Eupomatia laurina	530	1700	1166	245	780	2130	1572	328	1.34
13 Chloranthus spicatus	580	1630	1160	190	650	1780	1141	256	0.98
14 Cercidiphyllum japonicum	580	1330	1018	166	710	1650	1245	235	1.22
15 Galbulimima belgraveana	500	1410	1016	217	660	1740	1225	253	1.20
16 Austrobaileya maculata	580	1210	922	146	710	1600	1196	230	1.29
17 Schisandra repanda	390	1170	776	154	580	1410	996	168	1.28
18 Kadsura japonica	430	1020	731	158	570	1350	977	175	1.33
19 Degeneria vitiensis	410	1020	719	150	670	1680	1297	263	1.80
20 Euptelea polyandra	430	930	670	131	520	1310	921	154	1.37
21 Elmerrillia mollis	420	1000	654	128	550	1600	1077	254	1.64
22 Magnolia salicifolia	390	810	650	98	580	1520	1112	239	1.71
23 Liriodendron tulipifera	380	780	551	93	690	1400	1036	168	1.88
24 Magnolia sieboldii	340	740	514	104	440	1350	923	191	1.79
25 Magnolia hypoleuca	240	670	494	101	520	1220	936	164	1.89
26 Cinnamomum camphora	190	530	402	75	350	1100	738	180	1.83
27 Litsea citriodora	250	510	389	65	370	810	612	100	1.57
28 Hernandia nymphaefolia	170	530	385	89	340	900	661	120	1.71
29 Piper aduncum	170	510	379	58	350	950	684	145	1.80
30 Akebia trifoliata	340	680	447	75	340	850	600	132	1.34
31 Decaisnea fargesii	140	680	378	114	220	970	547	226	1.44
32 Paeonia suffruticosa	150	520	348	86	180	600	407	100	1.16
33 Nandina domestica	140	370	270	53	150	460	308	74	1.14
34 Mahonia japonica	150	380	248	42	170	470	321	62	1.29
35 Berberis thunbergii	140	370	243	51	140	640	352	100	1.44
36 Clematis stans	140	360	232	42	160	460	317	71	1.36
37 Clematis patens	110	360	228	58	160	470	266	63	1.16

Arrangement of species is the same as Tab. 1.

this study were more than 2 cm in stem diameter except for small shrubs. The materials were sectioned and macerated by the methods used by Takahashi (1985a). In every species examined, length of more than 50 macerated elements was measured. Diameter was obtained from more than 50 measurements of tangential diameter in the cross sections. From the values obtained, mean, standard deviation, F/V ratio (ratio of mean fiber length to mean vessel element length), and L/D ratio (ratio of mean length to mean diameter) were calculated. The values of L/D ratio were transformed to their natural logarithm (ln(L/D)).

Results Length of tracheary elements. The minimal, maximal and mean lengths, and the standard deviations of the vessel elements and fibers are given in Tab. 2 and plotted in Fig. 1. The values of F/V ratio were plotted against the mean length of fibers in Fig. 2. In the figure, F/V ratio of the vesselless species was expressed as 1.0. The vessel element and fiber were derived from tracheid, and then the difference between vessel element and fiber is smaller, the value of F/V ratio is closer to 1.0.

As shown in Fig. 1, five species of the vesselless dicotyledons (No. 1-5)

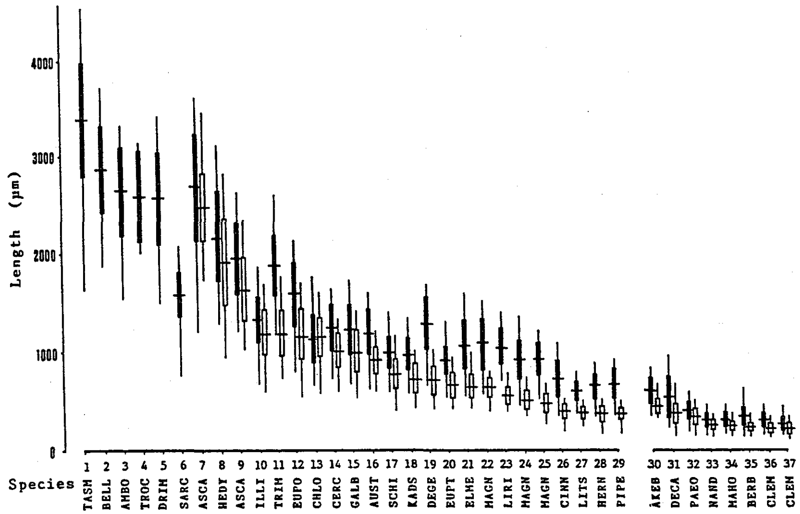

Fig. 1. Tracheary element length. Ranges, means and standard deviations shown by vertical lines, horizontal bars and rectangles, respectively. Solid rectangles: values of imperforate tracheary elements. Empty rectangles: values of vessel elements. Species are shown by the same numbers used in Tab. 1 and the first four letters of generic name.

have long tracheids of more than 2500 μm in mean length. Tracheids of *Sarcandra glabra* (No. 6, about 1500 μm in mean length) are considerably shorter than those of the other vesselless species. Vessel elements and fibers of *Ascarina* (No. 7, 9) and *Hedyosmum* (No. 8) are very longer than those of the other vessel-bearing families. *Chloranthus spicatus* (No. 13) has the shortest tracheary elements in this family, but the vessel elements are long in comparison with those of the other vessel-bearing families. In those four species of the Chloranthaceae, the vessel element length and fiber length are not so much different. In eleven species from No. 10 (*Illicium anisatum*) to No. 20 (*Euptelea polyandra*), vessel elements are 700–1200 μm and fibers are 1000–1800 μm in mean length. The range of vessel element length and that of fiber length overlap each other in the species in the case of longer vessel elements, e. g., *Illicium anisatum* (No. 10), and the overlapping becomes smaller as vessel elements become shorter. In five species of the Magnoliaceae (No. 21–25), vessel elements are 500–650 μm and fibers are 900–1100 μm in mean length, and there is a gap between the range of standard deviation of vessel element and that of fiber. In *Cinnamomum camphora* (No. 26), *Litsea citriodora* (No. 27), *Hernandia nympheafolia* (No. 28) and *Piper aduncum* (No. 29), vessel elements are about 400 μm and fibers are 600–700 μm in mean length, and there is a gap between the ranges of their standard deviations. In eight species of the herbaceous Polycarpicae (No. 30–37), tracheary elements are shorter than those of the woody species, except two species of the Lardizabalaceae (No. 30, 31). The range of vessel element and that of fiber overlap in those eight species.

F/V ratio of all 37 species examined shows the values under 2.0. The species are divided into four groups on the basis of relation of F/V ratio to mean fiber length, as shown in Fig. 2. The first group consists of vesselless plants (No. 1–5) whose tracheids are very long, more than 2500 μm in mean length, and values of F/V ratio are 1.0. The second group consists of five species of the Chloranthaceae (No. 6–9, 13), *Illicium anisatum* (No. 10), *Eupomatia laurina* (No. 12), *Cercidiphyllum japonicum* (No. 14), *Galbulimima belgraveana* (No. 15), *Austrobaileya maculata* (No. 16), two species of the Schisandraceae (No. 17, 18) and *Euptelea polyandra* (No. 20) whose fibers are more than about 1000 μm in mean length and values of F/V ratio are under 1.4. *Sarcandra glabra* (No. 6) is vesselless in the secondary xylem, but it is separated from the first group because its tracheids are distinctly shorter than those

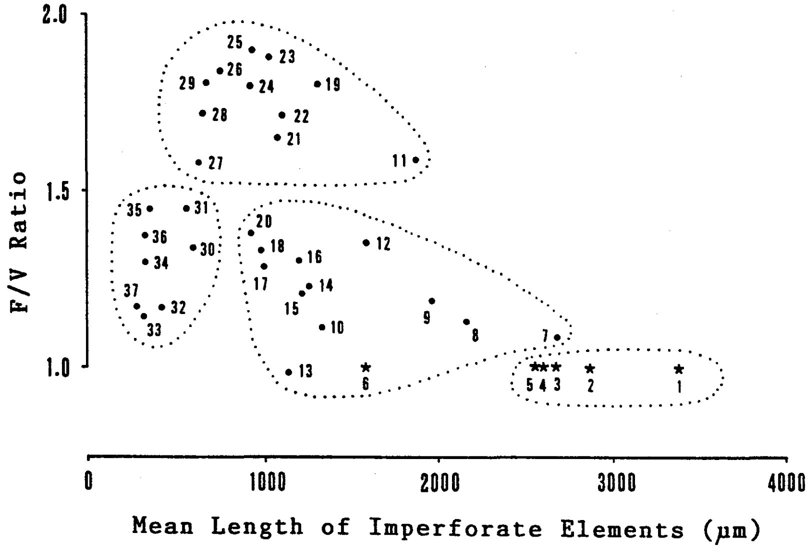

Fig. 2. Relation between vessel element length and fiber length. Values of F/V ratio plotted against mean length of imperforate tracheary elements. Stars show vesselless species. Species are shown by the same numbers used in Tab. 1.

of the other vesselless species. The species of the Chloranthaceae (No. 6–9, 13) are situated nearer to the first group as compared with the other members of the second group. The third group consists of *Trimenia papuana* (No. 11), *Degeneria vitiensis* (No. 19), five species of the Magnoliaceae (No. 21–25), two species of the Lauraceae (No. 26, 27), *Hernandia nymphaefolia* (No. 28) and *Piper aduncum* (No. 29) whose fibers are 600–1200 μm in mean length and values of F/V ratio are over 1.5. Fibers of *Trimenia papuana* (No. 11) are distinctly longer than those of the other members of this group, though F/V ratio is nearly the same. The fourth group consists of eight herbaceous species (No. 30–37) whose fibers are short, under 600 μm in mean length, and values of F/V ratio are under 1.5.

Diameter of tracheary elements and its relation with the length. The minimal, maximal and mean diameters, and the standard deviations of the vessel elements and fibers are given in Tab. 3 and plotted in Fig. 3. The values of ln(L/D) of the vessel elements and fibers are given in Tab. 3 and Fig. 4.

Tab. 3. Diameter of vessel elements and fibers, and their ln(L/D).

Species	Diameter (μm) Vessel				Fiber				ln(L/D)	
	Min.	Max.	Mean.	S.D.	Min.	Max.	Mean.	S.D.	Ves.	Fib.
1 Tasmannia piperita	-	-	-	-	12	48	26.3	7.8	-	4.85
2 Belliolum crassifolium	-	-	-	-	15	38	26.2	7.3	-	4.69
3 Amborella trichopoda	-	-	-	-	12	43	28.6	7.7	-	4.52
4 Trochodendron aralioides	-	-	-	-	8	30	18.7	6.1	-	4.93
5 Drimys winteri	-	-	-	-	13	43	27.0	7.5	-	4.55
6 Sarcandra glabra	-	-	-	-	7	35	20.8	7.0	-	4.33
7 Ascarina philippinensis	45	95	69.1	13.1	12	58	32.1	11.3	3.58	4.45
8 Hedyosmum orientale	42	90	56.6	11.1	8	53	29.6	11.0	3.52	4.29
9 Ascarina rubricaulis	45	93	67.1	13.6	12	55	30.3	12.1	3.19	4.16
10 Illicium anisatum	22	50	34.0	6.3	7	30	16.6	6.0	3.56	4.38
11 Trimenia papuana	40	90	69.4	11.2	8	60	23.3	11.6	2.84	4.39
12 Eupomatia laurina	35	65	49.3	7.2	8	43	20.2	9.1	3.16	4.35
13 Chloranthus spicatus	20	38	27.6	5.7	6	28	16.5	6.1	3.74	4.24
14 Cercidiphyllum japonicum	20	66	45.6	10.8	8	28	17.3	6.4	3.11	4.28
15 Galbulimima belgraveana	37	95	63.3	13.4	7	40	22.2	8.2	2.78	4.01
16 Austrobaileya maculata	30	105	55.6	20.6	8	33	20.1	6.1	2.81	4.09
17 Schisandra repanda	20	70	45.4	10.4	7	30	17.5	5.6	2.84	4.04
18 Kadsura japonica	22	75	40.9	11.3	7	30	16.6	5.7	2.88	4.07
19 Degeneria vitiensis	55	110	74.3	12.7	12	50	25.8	9.1	2.27	3.92
20 Euptelea polyandra	20	63	41.8	10.3	7	25	16.2	5.4	2.77	4.04
21 Elmerrillia mollis	42	140	92.5	24.0	7	45	20.4	8.6	1.96	3.97
22 Magnolia salicifolia	30	65	48.5	8.2	8	30	18.8	5.7	2.60	4.08
23 Liriodendron tulipifera	30	83	51.9	10.9	7	30	17.3	6.5	2.36	4.09
24 Magnolia sieboldii	35	70	49.7	8.4	8	32	17.4	6.0	2.34	3.97
25 Magnolia hypoleuca	32	68	49.4	9.4	9	32	19.9	6.6	2.30	3.85
26 Cinnamomum camphora	40	130	72.4	21.8	6	30	16.4	5.7	1.71	3.81
27 Litsea citriodora	32	70	53.9	8.7	6	23	14.6	4.7	1.98	3.74
28 Hernandia nymphaefolia	40	85	62.8	13.7	6	28	15.9	6.6	1.81	3.73
29 Piper aduncum	47	110	85.9	17.3	6	23	13.7	4.9	1.48	3.91
30 Akebia trifoliata	20	180	61.6	41.3	6	28	19.1	6.2	1.98	3.45
31 Decaisnea fargesii	20	68	46.3	13.3	5	28	15.2	5.5	2.10	3.58
32 Paeonia suffruticosa	15	50	30.3	10.7	6	22	13.6	4.5	2.44	3.40
33 Nandina domestica	10	55	18.4	7.7	5	17	9.2	3.2	2.69	3.51
34 Mahonia japonica	10	35	17.3	4.8	5	15	9.4	2.7	2.66	3.53
35 Berberis thunbergii	12	53	22.1	9.5	5	15	9.5	2.9	2.40	3.61
36 Clematis stans	18	128	43.8	25.5	5	23	13.2	3.8	1.67	3.18
37 Clematis patens	20	100	44.7	19.6	5	22	13.3	4.2	1.63	3.00

Arrangement of species is the same as Tab. 1.

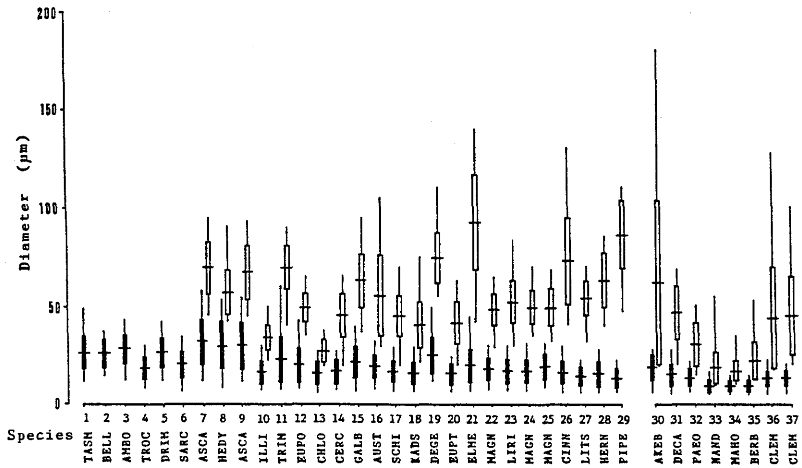

Fig. 3. Tracheary element diameter. Ranges, means and standard deviations shown by vertical lines, horizontal bars and rectangles, respectively. Solid rectangles: values of imperforate tracheary elements. Empty rectangles: values of vessel elements. Species are shown by the same numbers used in Tab. 1 and the first four letters of generic name.

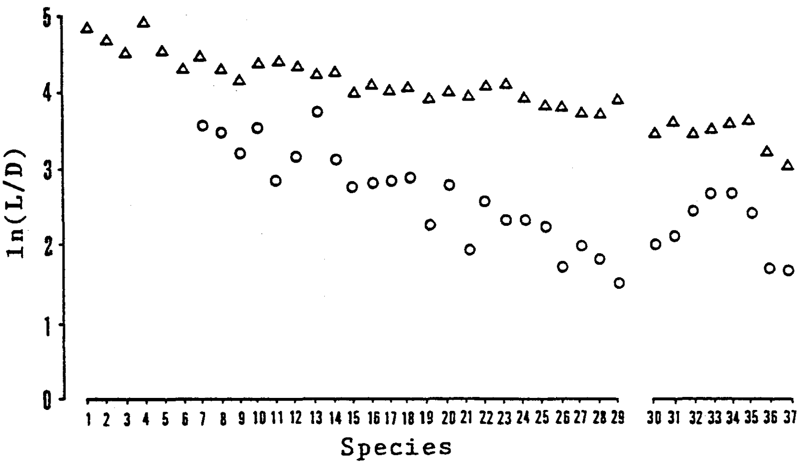

Fig. 4. Relation between length and diameter of tracheary elements. Triangles: values of imperforate tracheary elements. Circles: values of vessel elements. Species are shown by the same numbers used in Tab. 1.

As shown in Fig. 3, mean diameter of fibers varies slightly (9.2 to 32.1 μm), while that of vessel elements varies remarkably (17.3 to 92.5 μm). In the vessel-bearing woody species (No. 7 to 29), the difference between diameter of vessel elements and that of fibers is smaller in the lower numbered species and larger in the higher numbered species. In some species, whose mean diameter of vessel elements are less than 45 μm, i.e., *Chloranthus spicatus* (No. 13), *Illicium anisatum* (No. 10), *Cercidiphyllum japonicum* (No. 14), *Schisandra repanda* (No. 17), *Kadsura japonica* (No. 18) and *Euptelea polyandra* (No. 20), the range of diameter of vessel elements and that of fibers overlap each other. In *Degeneria vitiensis* (No. 19), five species of the Magnoliaceae (No. 21–25), two species of the Lauraceae (No. 26, 27), *Hernandia nymphaefolia* (No. 28) and *Piper aduncum* (No. 29) whose mean diameters of vessel elements are more than 50 μm, the range of diameter of vessel elements and that of fibers do not overlap. But in two species of *Ascarina* (No. 7, 9), *Hedyosmum orientale* (No. 8), *Trimenia papuana* (No. 11), *Eupomatia laurina* (No. 12) and *Austrobaileya maculata* (No. 16) whose mean diameter of vessel elements is also more than 50 μm, the ranges more or less overlap each other. In the herbaceous species (No. 30–37), diameters of vessel elements widely vary from 17 to 180 μm. In most species, the mean diameters are markedly lower than the middle of the ranges. The ranges between vessel elements and fibers more or less overlap each other.

In the woody species (No. 1–29), as shown in Fig. 4, values of ln(L/D) of fibers are arranged in a nearly straight line from maximum 4.93 (No. 4. *Trochodendron aralioides*) to minimum 3.73 (No. 28. *Hernandia nymphaefolia*), and those of vessel elements are also arranged in a nearly straight line from maximum 3.74 (No. 13. *Chloranthus spicatus*) to minimum 1.48 (No. 29. *Piper aduncum*). The gap between the value of ln(L/D) of vessel element and that of fiber becomes larger as the species number becomes higher. In the herbaceous species (No. 30–37), values of ln(L/D) of fibers vary from maximum 3.61 (No. 35. *Berberis thunbergii*) to minimum 3.00 (No. 37. *Clematis patens*), and those of vessel elements vary from maximum 2.69 (No. 33. *Nandina domestica*) to minimum 1.63 (No. 37. *Clematis patens*). The gap between the value of ln(L/D) of vessel element and that of fiber is small in *Paeonia suffruticosa* (No. 32) and three species of the Berberidaceae (No. 33–35), but slightly larger in the species of the Lardizabalaceae (No. 30, 31) and Ranun-

culaceae (No. 36, 37).

Discussion The tracheary elements of the woody Polycarpicae observed in this study vary in length which suggests that the group includes the elements on various evolutionary stages. In the Austrobaileyaceae, Chloranthaceae, Eupomatiaceae, Illiciaceae, Trimeniaceae, etc., which are regarded as primitive members of the woody Polycarpicae, the vessel elements and fibers are long and not so much different from each other in length and the F/V ratio is low. On the other hand, in the Hernandiaceae, Lauraceae and Piperaceae, which are considered to be advanced, the tracheary elements are short. The fibers are distinctly longer than the vessel elements and a gap is recognized between them, and F/V ratio is high.

In gymnosperms, the lengths of tracheary elements of *Chamaecyparis*, *Cryptomeria* and *Ephedra* were measured and compared with those of the Polycarpicae. The tracheids of *Chamaecyparis obtusa* (2490 μm in mean length) and *Cryptomeria japonica* (3113 μm in mean length) are nearly the same in length with those of the vesselless dicotyledons. The tracheary elements of *Ephedra pachyclada*, as will be mentioned later, are closer in length to those of the herbaceous Polycarpicae than to the woody ones. In non-polycarpicean angiosperms, such as Aquifoliaceae, Compositae, Fagaceae, Rosaceae, Styracaceae, etc., the lengths of tracheary elements were measured. The tracheary elements of these families are not so long, fibers are less than 1 mm and vessel elements are less than 600 μm in mean length. In most species, values of F/V ratio are between 1.5 to 2.0, but in *Artemisia stelleriana* (Compositae), *Prunus yedoensis* (Rosaceae) and *Quercus glauca* (Fagaceae), values of F/V ratio are high, more than 2.0, while in some species of *Ilex* (Aquifoliaceae), the values are low, about 1.3. If those values are plotted in Fig. 2, they fall into the area of the third group of the Polycarpicae (fiber length is less than 1 mm and F/V ratio is more than 1.5). According to Carlquist (1988), F/V ratio of the angiosperms is about 2.0 in general. But in many species of the woody Polycarpicae examined in this study, values of F/V ratio are remarkably low (1.1 in *Ascarina philippinensis*, *Hedyosmum orientale* and *Illicium anisatum*, 1.2 in *Ascarina rubricaulis*, *Cercidiphyllum japonicum* and *Galbulimima belgraveana*, 1.3 in *Austrobaileya maculata*, *Eupomatia laurina*, *Kadsura japonica* and *Schisandra repanda*), and they are considered to be in the primitive stages.

In the woody Polycarpicae, a tendency is recognized that as the vessel ele-

ments become thicker, the differences between the diameters of vessel elements and those of fibers become greater. But there are some exceptional cases. Comparing *Ascarina* with *Magnolia*, the diameter of vessel elements is more in the former but their difference from the diameter of fibers is apparently greater in the latter. In general, as tracheary elements become shorter, the diameter of vessel elements becomes wider, but the diameter of fibers does not become so wider as in the vessel elements. Carlquist (1988) pointed out that "vessel widening, while apparently operative at the outset of vessel evolution, should not be considered as a measuring-stick of wood evolution." As far as examined in the woody Polycarpicae, however, the diameter of vessel elements can be a measuring-stick of wood evolution to a certain extent when combined with the length.

In *Sarcandra glabra*, the tracheids are distinctly shorter than those of the vesselless dicotyledons and close to the vessel elements. *S. glabra* had been regarded as a member of the vesselless dicotyledons (Swamy & Bailey 1950, Swamy 1953), but recently vessels were detected in the xylem (Carlquist 1987, Takahashi 1988). The vessel elements of the other genera of Chloranthaceae are not so different from the tracheids of *S. glabra* and the vesselless dicotyledons in length, F/V ratio and ratio of length to diameter (ln(L/D)). The tracheary elements of Chloranthaceae may show the transition from tracheids to vessel elements and fibers.

The vessel elements of the herbaceous Polycarpicae are generally shorter than those of the woody ones. On the contrary to the woody Polycarpicae with short vessel elements such as Hernandiaceae, Lauraceae and Piperaceae, the length of vessel elements and that of fibers of the herbaceous Polycarpicae more or less overlap each other and F/V ratio is low, and their diameters also overlap. As mentioned above, in a gymnospermous species, *Ephedra pachyclada*, the vessel elements and fibers are moderately short (658 μm and 713 μm in mean length) and F/V ratio is very low (1.08), somewhat similar to those of the herbaceous Polycarpicae. The low F/V ratio in the herbaceous Polycarpicae may suggest that their tracheary elements are short but not so specialized. In the short vessel elements of herbaceous Polycarpicae, e.g., in *Decaisnea* (Takahashi 1985b), the scalariform perforations are reported, and sometimes in Ranunculaceae (Avita & Inamdar 1981).

We wish to express our cordial thanks to Prof. Dr. K. Yashika, Osaka University, for his encouragement throughout this study. Thanks are also due to Dr. T. Yamazaki, University of Tokyo, Dr. H. Okada, Osaka University, Dr. M. Suzuki, Kanazawa University, Dr. S. Terabayashi, Tsumura Laboratory, Dr. K. Ueda, University of Osaka Prefecture and Dr. K. Kosuge, Kobe University, for the supply of materials.

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木本性多心皮類14科29種と草本性多心皮類4科8種において，木部管状要素の長さと直径を計測し，それらにおける進化傾向を明らかにしようと試みた。長さに関して，木

本性多心皮類のうち原始的とされている種では道管要素と繊維は共に長く，両者の差が小さいが，特殊化しているとされる種ではそれらは短く，差も大きいという傾向が認められる。道管要素の直径が太くなれば繊維の直径との差が大きくなる傾向はみられるが，これに従わない場合も多い。直径と長さを関連づけてみると，一般に道管要素は長さが短くなると直径が大きくなるが，繊維は長さが短くなってもそれほど直径が大きくならない。従って，道管要素が短くなるにつれ道管要素と繊維との差が大きくなるという傾向がみられる。裸子植物および他の被子植物と比較すると，多くの木本性多心皮類の道管要素と繊維は長さや直径に関する値からみて原始的状態にあると思われる。とくにセンリョウ科の管状要素は，仮道管から道管要素と繊維とに至る移行段階を示していると思われる。一方，草本性多心皮類の道管要素は，木本群のものに比べて長さが短いが，道管要素と繊維の長さは差が小さく，またそれらの直径の差も小さい。そして，これらの要素は短いけれどもそれほど特殊化していないことが示唆された。

□Gottlieb, L.D. & S.K. Jain (ed.): **Plant evolutionary biology** 414 pp. 1988. Chapman & Hall, London. ¥7,650. G.S. Stebbins の流れをくむ population biology の発展を期して，1989年にカリフォルニア大学で開かれたシンポジウムのまとめである。米国を主とし，英国，カナダ，イスラエルの研究者19名が14章を分担執筆している。分子，細胞器官，タクソン，繁殖機構，発生，形態，集団などいろいろなレベルでの事象が進化・系統に結びつけて論じられ，ところどころに編者の意見が挟まれており，読みでのある一編である。 (金井弘夫)

□小国生物友の会：**小国の植物** 1989. 小国町は新潟県のほぼ中央，柏崎市と小千谷市とに挟まれた東西 10 km，南北 12 km ほどの丸い地域で，中央を南から北へ渋海川(信濃川の支流)が貫き，周囲を 200～500 m の山が取り囲んだ盆地になっている。冬は豪雪，夏は高温多湿という四季の変化が著しい関係で，植物に恵まれた場所であるという。この本は地元の研究者の集まり「小国生物友の会」の12名の方々が，多年の研究の成果の一端を図鑑にしたもので，植物目録は追って発表する予定になっている。小国町で撮った500種の植物生態写真を，草本の春・夏・秋と木本そしてシダに分け，毎ページ1～3図，図ごとに方言なども混えた説明がある。色のよく出た印刷で特徴がよく出ていてわかりやすい。定価は付いていない。上記の会（〒949[redacted] 新潟県刈羽郡[redacted] 高橋 実，振替 新潟 7-5114）へ2,000円と郵送料390円を払込めば入手できる。 (伊藤 洋)